CHAPTER I
INTRODUCTION

1.1 Prologue

The globalization of business brings many challenges for the Information Technology (IT) industry. There is a continuous demand for bringing together customers, partners, supplier and employees across geographies with high levels of visibility, control and responsiveness. The changes in the market place are very high due to mergers and acquisitions, changes enforced by government laws and high competition. It becomes essential that the IT needs to respond to these business changes efficiently with minimum impact on the existing business. In other words, the enterprises which are agile to these changes are successful.

The expectation of the IT division is very high and the business leaders are expecting that the IT should connect the people, processes and information quickly for the changing business scenarios. It is expected that the IT should run the business without any downtime of the applications in order to keep the businesses running. Is this a possibility in today's scenario? What all challenges are there? In order to understand the existing challenges, we need to look into the history of IT and how they had evolved over the period of time.

IT has evolved over a period of 40 years and it has its own strengths and weaknesses. During the initial days, IT has enabled business process efficiencies and business flexibility to a large extent. The applications which were built over the period of time had provided rich functionality in all areas like finance, marketing, supply-chain management, customer relationship management, etc. While they provide the required functionality at an independent level, the integration and data exchange between these applications were always a challenge. They were not able to share information with one another and therefore

cannot provide the required flexibility and agility. To achieve the information transfer between different disparate and incompatible applications, some of human intervention (like re-entering the data in different applications) or a custom interface between the applications is necessary. These mechanisms are expensive and inflexible when there is a change in the underlying application.

When the applications in silos are connected using tightly coupled manner, any changes which are happening in the underlying applications will create issues. When the number of applications in the organization becomes more, it becomes much more challenging. Fig 1.1. shows a snapshot of an enterprise which has connections between applications.

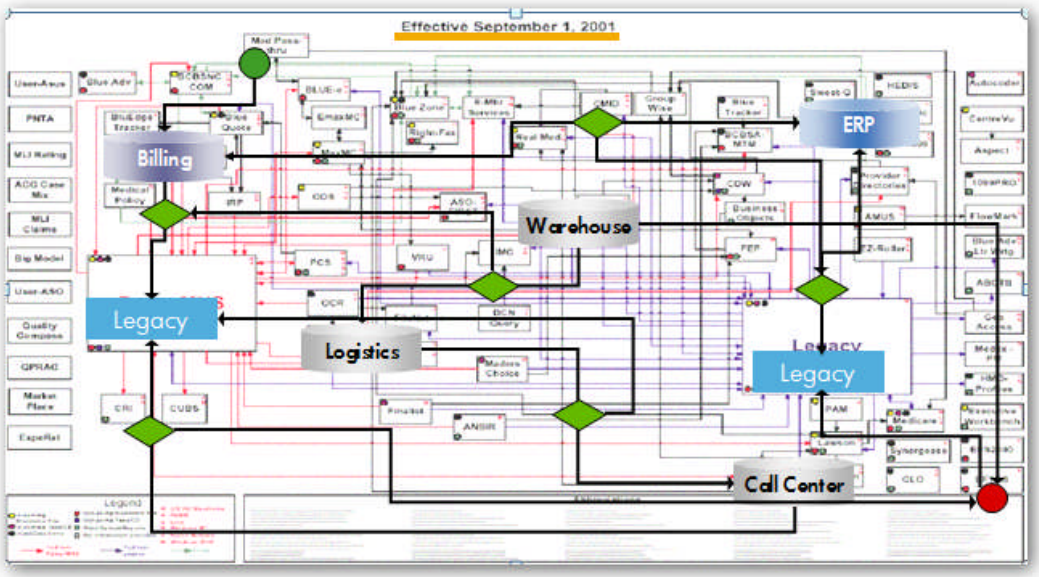

Fig 1.1: IT Challenges in today's environment

As shown in Fig 1.1, in order to have the data flow between the different applications, the custom interfaces are built using the specific protocols. For example, if the Billing application is written in Foxpro and the Legacy application is written using COBOL, the interface between them are tightly coupled in such a way that it can understand each other's protocol. This becomes challenging whenever there is a change in the application landscape. In this case, if the billing

application is replaced with another application, the interface with the legacy application needs to be changed and tested. As shown in the picture, the complexity increases when the number applications also increase.

What is needed in today's business? It needs to connect processes, people and information both within the organization and across organizations boundaries or partners. The market place is extremely competitive and organizations need to capitalize new business opportunities faster. The business processes continues to change at a faster pace based on various parameters like change in government regulations, mergers & acquisitions, to improve the efficiency, to bring new technologies, etc. However, it is commonly known that IT cannot move fast enough or enough flexibility to compete effectively. This inflexibility increases costs, decreases customer responsiveness, hinders compliance and decreases worker productivity.

We have seen a large number of applications and solutions deployed in large enterprises. In the past 40 years of IT era, there are multiple reasons why there are many applications in the enterprises. The IT managers had started managing their IT infrastructure with the help of popular technologies. Due to lot of technology changes over the period of time, the enterprises had invested lot of money in getting new technologies without realizing whether it is really needed. This had introduced lots of challenges and there is always pressure for the IT department in order to get the Return On Investment (ROI). While some enterprises were investing in latest technologies, some of the enterprises had not changed over the period of time and hence they have lots of legacy applications. They are out-dated in the market which makes it difficult to get the necessary support from the vendors and also difficult to get the knowledgeable resources. In our opinion both these approaches will not help in anyway the business to be executed effectively and efficiently.

IT plays a major role for the business to be flexible and agile in order to compete effectively in the market place. IT needs to show their flexibility by integrating different applications and change as per the business needs. Since the IT had grown for the past 40 years having different platforms and technologies, it is not integrated as needed by the business or it is integrated for a specific purpose and makes it difficult to change it. In short, a lack of integration is the biggest challenge that organizations face in their efforts to remain competitive and grow.

The industry had been looking for some kind of a solution in order to resolve the integration issues which had grown for a period of time. Gartner had predicted that Service Oriented Architecture will become a prevailing software-engineering practice, ending the 40 year domination of monolithic software architecture.

Service Oriented Architecture (SOA) is really about fixing existing architecture issues by addressing the major systems as services and they are formed into solutions as needed. This seems to be a valid approach to solve many of the architectural problems that enterprises faces today. SOA is a design approach which organizes the existing IT assets such that the heterogeneous array of distributed, complex systems and applications can be transformed into a network of integrated, simplified and highly flexible resources. SOA is becoming a widely accepted approach in order to achieve the flexibility and agility without replacing the existing IT applications and infrastructure. The section 1.2 provides an overview about the SOA.

1.2 SOA Overview

In order to resolve the existing problems, we cannot bring more software to solve it which will not help. The industry experts think there should be a better way of architecting the IT solutions which are aligned with the business needs.

The motivational factors for SOA implementation in the enterprises are as follows:

- The core business motivation is business flexibility
- The existing legacy systems investment needs to be protected
- IT should be agile towards the business changes
- Driving companies to find new ways to grow business and operate more efficiently
- IT expenditure to be reduced by increasing productivity
- Improve in decision making process

In the current business environment the IT department in the enterprises seems to be extremely slow in responding to the changes happening in the market place. In the globalization trend, mergers and acquisitions are very common and during this process, the IT takes longer time for merging the enterprises than any other division like marketing, finance, human resources, etc. It is common that the enterprises which are part of these mergers have their IT landscape as shown in Fig 1.1. Any change which happens within one enterprise itself is difficult to manage and merging these two complex entities makes the complexity multi-folded. What could have been done in order to make it more agile for these enterprises? The experts think that the service orientation could be one approach which makes enterprises flexible enough to accommodate such changes.

The SOA is not a solution or a product or software that can be installed in the enterprise that can solve all the problems. It is an architectural pattern and approach for decomposing the applications into services. A typical SOA implementation in an existing enterprise will be a three step process. The first step would be a “Discovery & Planning” phase in which the enterprises will understand what is SOA and the benefits of SOA for their enterprises. In the second step, typically a pilot project is implemented with a set of services and as the final step, enterprise-wide SOA adoption is done.

The identification and implementation of services is a key aspect in the SOA implementation. During this phase, if the enterprises have many legacy applications, the services will be built in top of these applications which exposes the underlying application capabilities. In this case, the services will interact with the application through the proprietary protocol in the south-bound and expose a standard interface (as a web service) in the north-bound.

In the existing systems, there is a gap between the business and IT which makes difficult for IT to accommodate the business changes which are happening. This gap is extremely large because the IT is more technology oriented and the businesses are process-oriented. It is believed that the SOA definitely bridges this gap with the service orientation. Once the services are built and available, the business processes as defined by the business are realized using the service composition or orchestration. The composition is a process of defining the service execution as a flow and as part of this flow, the services are executed.

In summary, the services are built on top of the legacy applications and through service composition, the business processes are implemented. In this approach, any changes in the businesses are done at the service composition level which will not affect the underlying applications. In case of any changes at the application level, as long as it exposes the standard interfaces as defined and agreed by all stakeholders, the impact is extremely low.

While implementing SOA in an organization, one of the important aspects is the governance for the design-time which is part of the service life-cycle. There are maturity models defined by different companies in order to understand each organization on what level of maturity they have with respect to the SOA. At the highest maturity level, it is expected that the organization is agile where the environment has a continuous change culture and business processes. The business processes adapts to the changes which are happening at the service level

through automatic processing. It is understandable that each organization who is adopting SOA wanted to reach the highest maturity level possible.

We took this as a basis and continued our investigations on what it takes for the organization to reach this level. We started looking at some of the other research areas around web services which is considered as a building block for the SOA. We found that the semantic web and other technologies could be the next disruptive technologies. The section 1.3 provides a brief overview about the semantic web.

1.3 Semantic Web

Looking at the history of the internet, it is clear that there are three different versions called Web 1.0, Web 2.0 and Web 3.0. The Web 1.0 era is based on simple principles. The web pages were developed using the HTML and HTTP is used to retrieve the information. All the pages were identified through URIs. In this case, the information was published by web site owners or authors and the internet users can only view this information. In other words, the entire web was based on read only mode because the users can only read the content. In late 2004, the Web 2.0 came into usage which facilitates the interaction, information sharing, interoperability, user-centered design, etc. Based on this, the social networking sites like Facebook, Orkut, flickr came into usage. In this model, the users are not only viewing the content, they can also contribute in terms of content and other contents like pictures, videos, etc. In this Web 2.0, some of the major breakthroughs are blurring the distinction between the service providers and service consumers, media had moved from individuals to communities, innovation had become a key in this.

With Web 2.0, the users had become extremely active and the penetration of internet had happened in all walks of life. The common people at all ages have

started using the Web and in general there was a huge excitement around the web. The question is, after the Web 2.0, is really the internet had become useful? Is there any more limitations in the current form of the web? There are still limitations in the current web. Some of the limitations are in terms of finding the relevant information, extracting relevant information and combining it for further usage. In the current Web, finding the information always happens with keywords. For example, if we are searching information about cars using the keyword “cars”, then the search will not retrieve the pages if the author had used the word “automobile” instead of the word “car”. The words might have many synonyms and it depends on the user on what keywords are used to search the content. Similarly, extracting the information from a web page through a standard process is not possible because each web page provides the information in different formats. When a user searches for information, there is a possibility of combining information from several web pages in order to achieve a goal. For example, if a person is travelling to New Delhi, he will be searching for the flight ticket, followed by taxi booking and then a hotel booking. In today’s web, the user had to search independently and combine this information manually. It will be extremely useful if the user specifies the goal and the web starts finding the relevant information and combining it appropriately. These limitations are part of the existing web because the information which are available in the web are not machine understandable.

In order to resolve some of these issues, there is a major step in defining the meaning for the web which is called as Semantic Web. This is also known as Web 3.0, the next generation of World Wide Web. In the semantic web, the information has machine processable and machine understandable semantics. The backbone of the semantic web is Ontologies. The ontology is used to define the concepts, its properties, relationships and axioms. Using Ontology the semantic for each word or a person or job or anything can be defined. Using the appropriate algorithm and logic, these Ontologies are understood by machine for further processing. In the

semantic web, the web is annotated which makes this as a web of data compared to the existing web which is a web of documents or links.

The semantic web concept is extended to the web services which makes it as semantic web services. We believe the semantic web services will make a lot of difference in future because it provides very powerful features. In the existing web services world, only syntactic information about the web service can be represented using web services description language. For example, if there is a web service which provides the weather of a city, the web service description language provides information on the method name, the parameters, types of input and output parameters. The machine cannot understand the meaning of weather and city which are semantics of this service. In the semantic web services, with the help of Ontology, the semantics can be represented.

The semantic information for the web services provides a new opportunity called as “automatic web service composition”. There are many researches happening in this space. There are many algorithms proposed by different scholars based on mathematical models, artificial intelligence and so on. We have seen one of the existing problems in the current web service model is the service composition. The developer who creates the service composition needs to understand the meaning of each web service before composing it. This becomes a big challenge when the number of web services becomes more. In the present scenario, all the enterprises and social networking sites exposes many web services and the number of services are increasing in terms of thousands. Hence the challenge of web service composition becomes more.

In the semantic web services, the semantics of the web services are expressed in terms of ontology. The ontology is machine understandable which makes the automatic web service composition possible. We believe that the semantic web

service usage in the industry will solve some of the issues which are existing in today.

1.4 Motivation

The evolution of SOA had changed the way the Software Development Life Cycle processes (SDLC) in the enterprises. The traditional SDLC approaches were focusing more on the development and leverage or reuse of existing components or services were not considered to a large extent. There are some changes needed in the each phase of the SDLC processes especially in the way the integrated processes or applications are tested.

SOA is receiving all this attention because of the great potential value it offers to those who pursue it. If an organization achieves a mere fraction of the total potential value of SOA, it will be significant to that organization's profits, competitive posture, and overall operational effectiveness. That is why SOA is such an important strategic initiative to pursue. SOA makes too much sense technically and financially to implement.

SOA is one of the important recent trends which are adopted by enterprises in different domains such as telecom, finance, retail industries, manufacturing, etc. There are standard bodies and organizations which defines the web service interfaces in order to have a common implementation across different vendors. While it is getting popular, there are enough challenges in this architecture. As mentioned earlier, service composition is one of the key concepts and it is used to create the applications quickly by integrating individual atomic services. This becomes more challenging when the number of services that can be used is very high.

Similarly, the SOA governance is also important but has some limitations in the run-time governance which exists today. The policies which will be associated with a service are of static nature and it cannot be changed dynamically. Any change requires re-deployment of those services which affects the production systems.

In the other side, the semantic web technologies are growing rapidly especially on the semantic web services. There are many researches which are being done on the automatic discovery and automatic composition of web services based on the semantic information associated with the web services.

The SOA and semantic web technologies are two different technologies which are extremely popular and numbers of scholars are working in these areas. Looking at the challenges of service creation, SOA run-time governance and the growth of the semantic web services, it provides a great motivation on the application of semantic web technologies in these areas and observe the results.

1.5 Statement of the Problem

There is an increase in the industry on the SOA based projects in different domains like telecom, finance, manufacturing, etc. The numbers of services which are available in the internet are also increasing. The need for service composition by integrating the services which are available within the enterprise and in the internet is becoming more important in order to be more agile and competitive in the market place.

There is a definitive need for a proper software engineering modeling for SOA based projects. The software engineering approaches for SOA projects includes different tools and techniques that can be applied to enhance the productivity,

metrics for successful implementation and testing methodologies for verification. This is a broad scope in which lot of research can be done.

For this thesis, the scope of the software engineering modeling for SOA based projects is considered on the following concepts:

- **SOA Governance**: As part of the service development during the SOA implementation, it is important to have the SOA governance in place in order to bring in more control. Design-time governance brings the control during the development time and run-time governance brings the control during the execution of the services by the end-users. The existing implementation of run-time governance has limitations because it is of static nature. This thesis discusses on how the semantic web services can be used in order to bring the dynamic run-time governance. This proposes a system by applying the semantic web.
- **Service Creation**: The service creation in this context is usually referred to service composition in the context of SOA. The developer who needs to create the service composition needs to understand each service available in order to use it during the composition. This becomes challenging when the number of services are more. Hence, this thesis proposes a system of service creation aspect with the help of semantic web services concepts. The application of semantic concepts will bring more efficiency and productivity.

1.6 Thesis Organization

The thesis is organized into six chapters. The first chapter is introductory in nature and provides the motivation for this thesis along with the statement of the problem. The rest of the chapters are organized as mentioned below:

Chapter 2: Literature Review

This chapter presents the review of literature relevant to the thesis. This includes the topics of service-oriented architecture, capability maturity model (CMM) for SOA, governance aspects of SOA, web services, semantic web services, automatic composition for semantic web service techniques are presented.

This literature review had provided the understanding of fundamental concepts of various topics and different perspectives provided by different experts and finally the research areas happening in the academic side.

Chapter 3: Dynamic SOA runtime governance

This chapter provides the fundamental concepts of the governance aspects. As part of the governance, the policies and SLAs are studied in detail. It also provides the technical aspects of the architectural framework called web service intermediaries. The discussion on how the existing SOA governance is implemented with web service intermediaries are presented. Based on the limitations of the existing system, the need of runtime governance for SOA is discussed. The dynamic SOA runtime governance concept is introduced using semantic web services with the help of a proposed system.

Chapter 4: Service Creation for SOA based solutions in Telecom Domain

This chapter discusses in detail about the service creation in terms of composed service. The challenges in terms of new service creation because of services growth are discussed. In order to understand more about this problem, the telecom domain is considered and the concept of Service Delivery Platform (SDP) is introduced. As part of the SDP, the service creation especially the service composition is part of the functionality. The service creation challenges are

discussed in the context of SDP through the SDP reference architectures from the industry standard bodies. The semantic web services concepts are introduced here and reference architecture based on semantic web services for SDP is proposed and discussed.

Chapter 5: Methodology and Results

This chapter provides the research methodology followed for experiments and the results. For this thesis, two experiments such as dynamic SOA run-time governance and service creation for SOA based solutions. In order to perform these experiments, web services, semantic definitions like ontology creation, goal definition, capability definition, etc. are done. The details of this along with the screen shots of the WSMO studio tool are explained in detail.

The experiments were performed with the set of sample data and the input/output based on these sample data are explained. The results are discussed and the interpretations based on the results are documented in this chapter.

Chapter 6: Conclusion and Future Work

The thesis is concluded in this chapter, with a summary of the key findings from the research work carried out. A promising direction for further research work is presented.

A bibliography is appended to the thesis. So is a list of publications and the conferences attended by the candidate - national as well as international are listed.